

MEMS & Micro Power Generation (MPG)

DARPA Tech 2000

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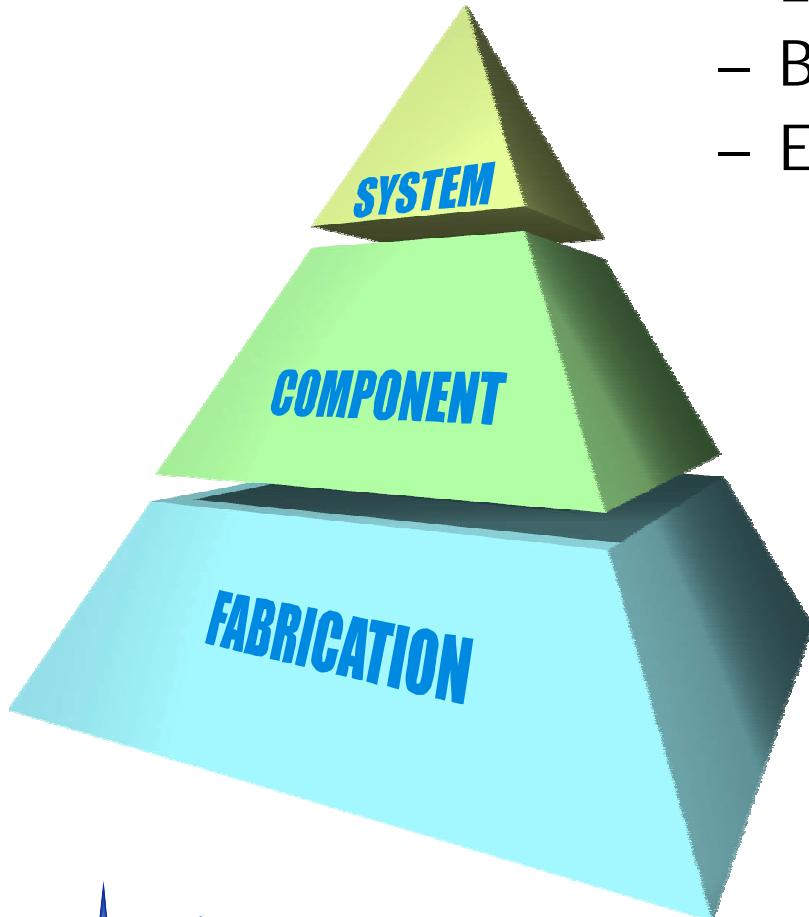
<http://www.darpa.mil/MTO/MEMS>



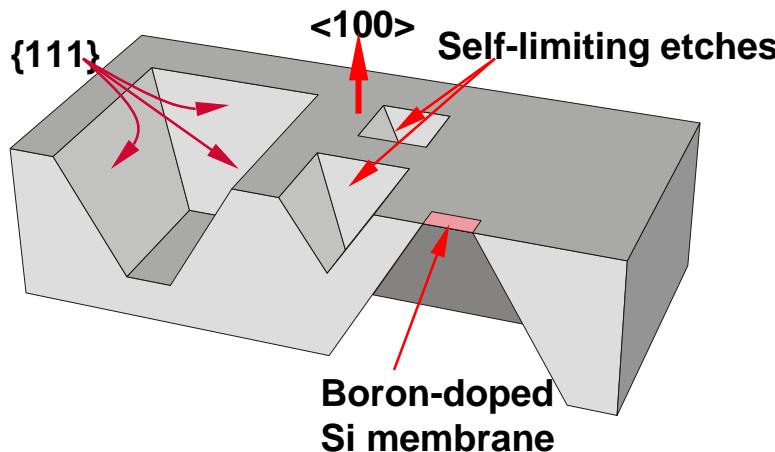
Micro Electro Mechanical Systems – A Core Technology

MEMS is a core technology that:

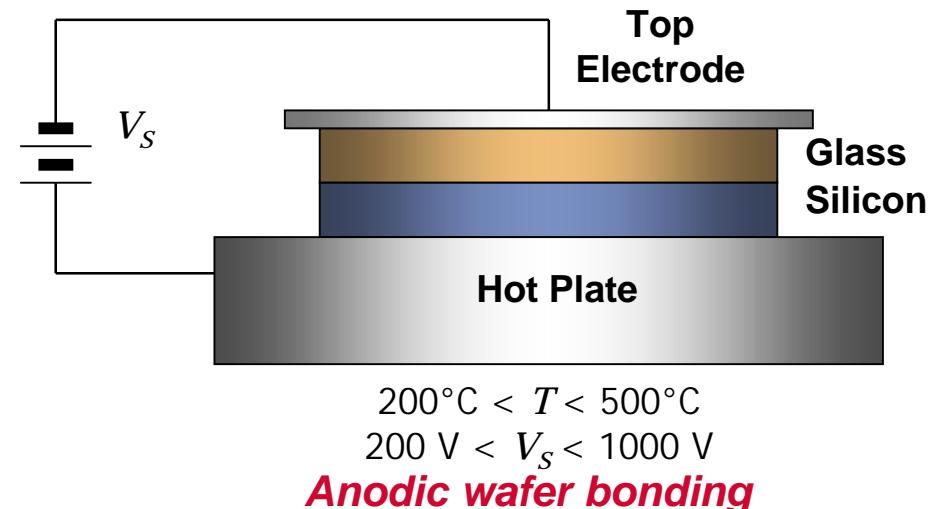
- Leverages IC fabrication technology
- Builds ultra-miniaturized components
- Enables radical new system applications



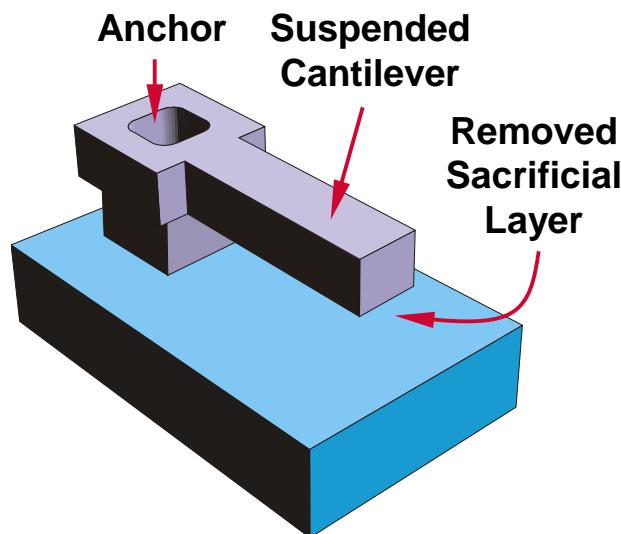
MEMS Fabrication Technologies



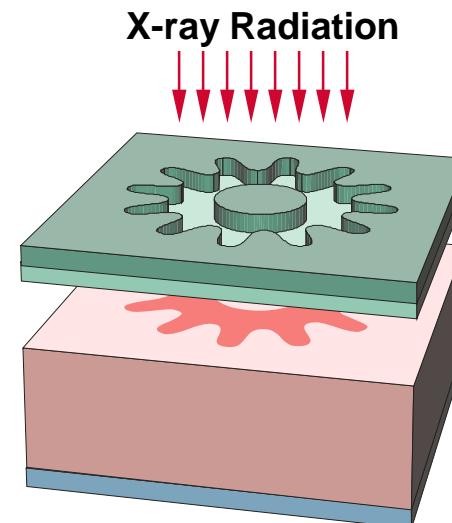
Anisotropic bulk etching



Anodic wafer bonding

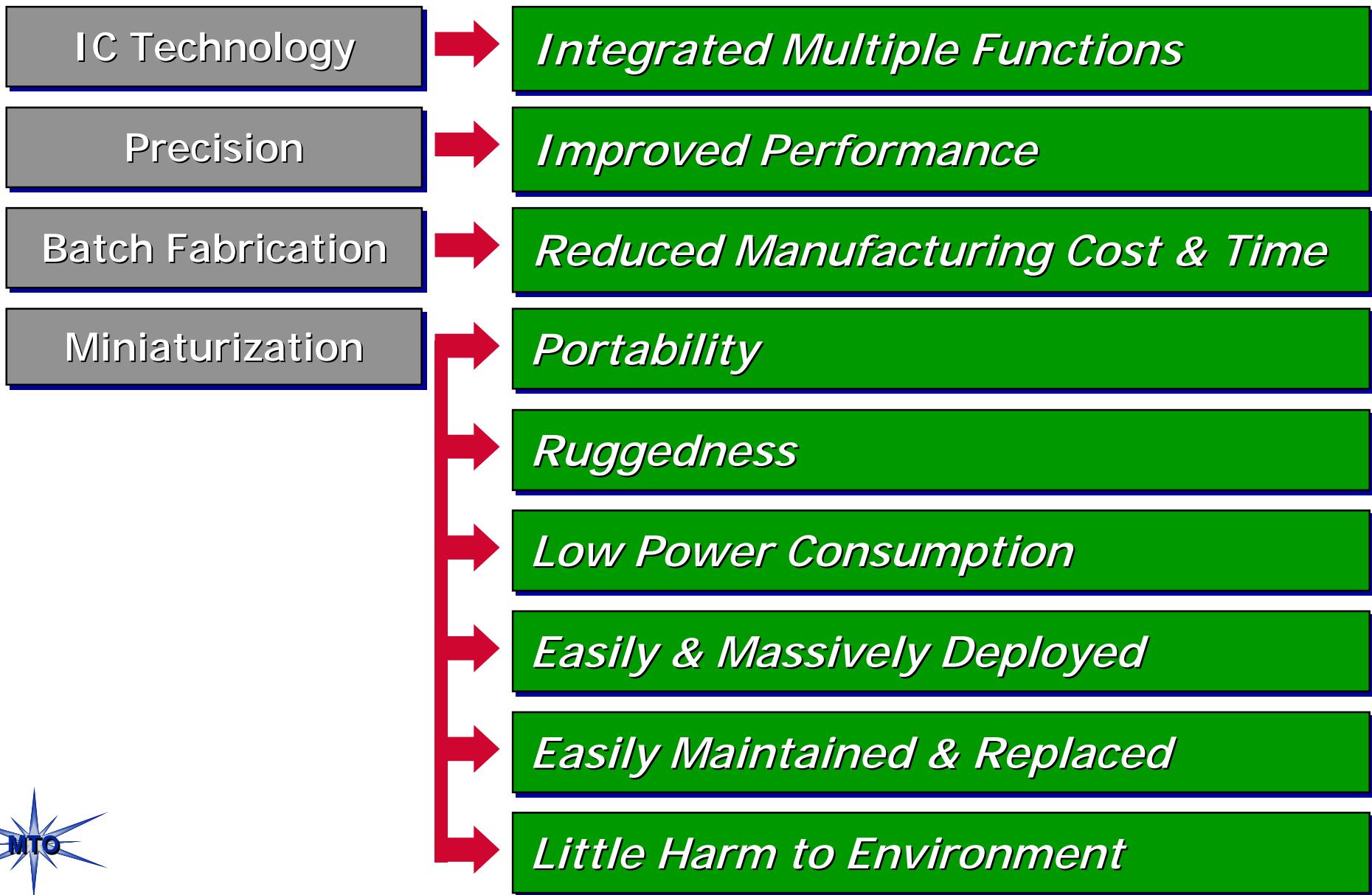


Surface micromachining



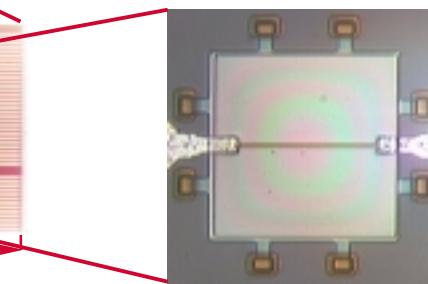
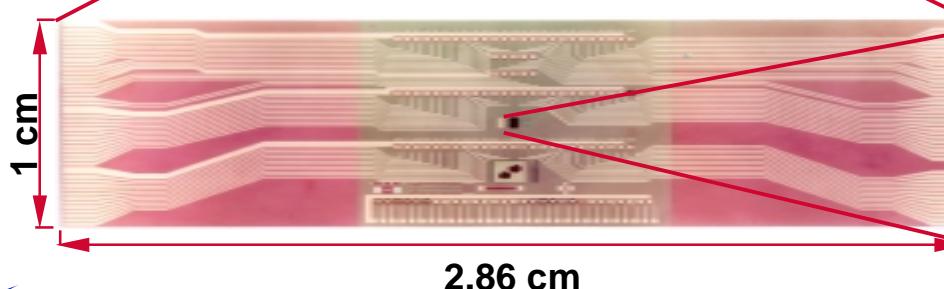
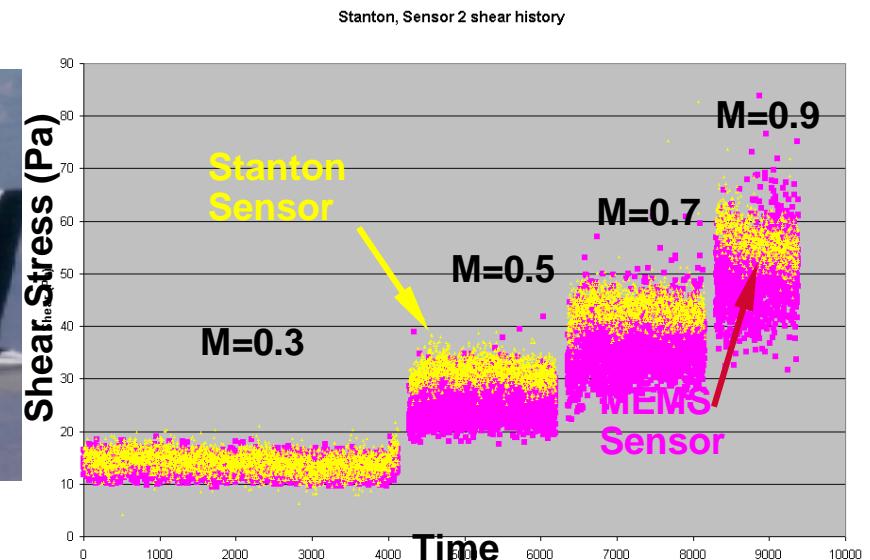
LIGA

Advantages of MEMS



Shear Stress Sensor for Jet Fighter (Caltech)

- Demonstrated 10X more bandwidth over state-of-the-art sensors in F-15 flight test (co-funded by NASA)



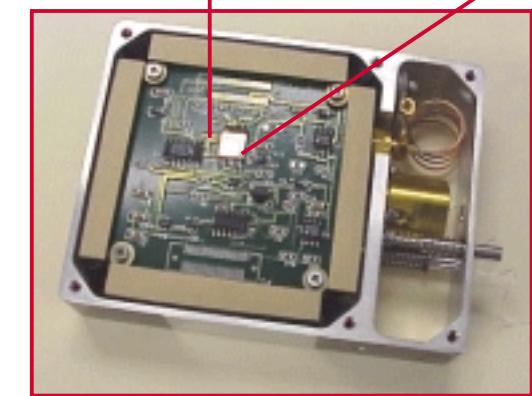
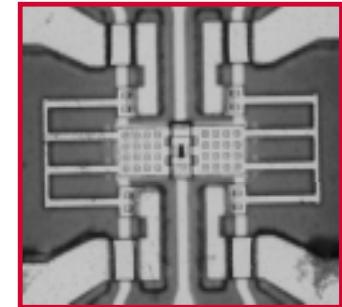
**MEMS shear-stress sensor
($200 \mu\text{m} \times 200 \mu\text{m}$)**



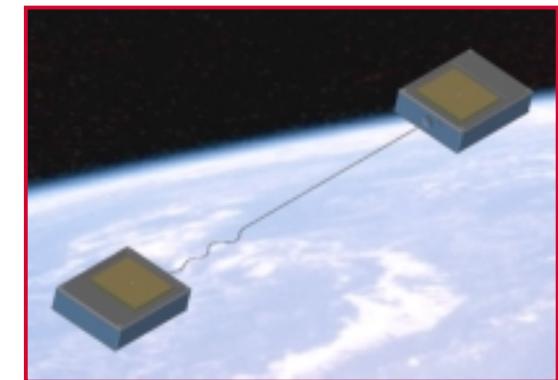
Pico Satellites (Aerospace Corp., et al.)

- ❖ Pico satellites
 - Weight & Size: 250 gm, 2.5 x 7.5 x 10 cm
 - A platform for testing MEMS devices and microsystems for space applications
- ❖ Potentials
 - Cooperative constellations
 - Sparse aperture antennas
 - Inspect and service missions
 - Launch-on-demand, robust communications, and surveillance space systems
- ❖ First demonstration:
 - Launched 26 Jan 2000
 - RF communication established 7 Feb 2000
 - Operated MEMS RF switches in space

MEMS RF Switch
(Rockwell)



Pico Sat (Aerospace Corp)

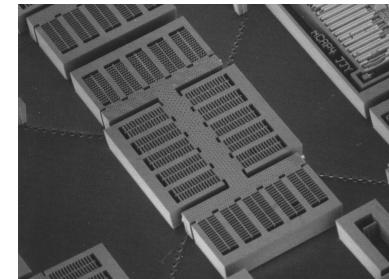
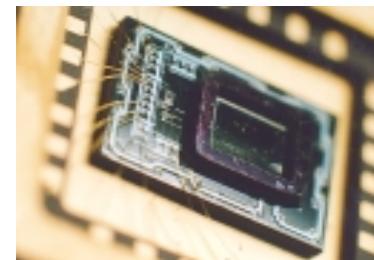


Wireless Integrated Network Sensors (UCLA, et al.)

- ▶ Demonstrated embedded processor, radio links, multihop network, and seismic/acoustic sensing
- ▶ Condition-based maintenance, battlefield awareness, health monitoring, environmental monitoring, etc.

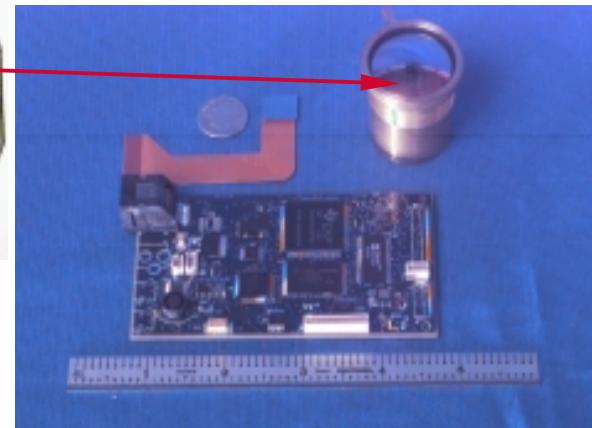
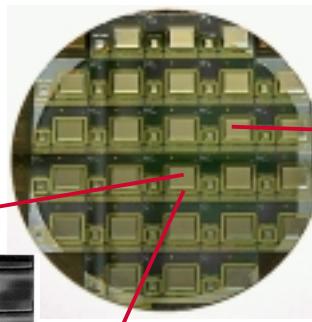
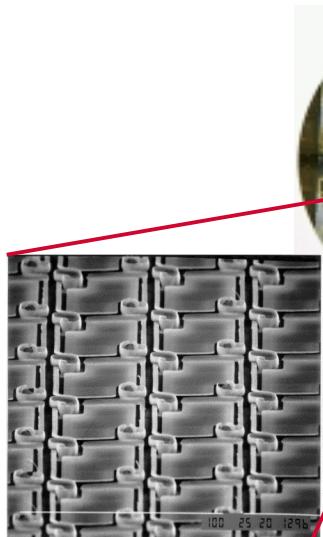


Army NTC / Aberdeen PG

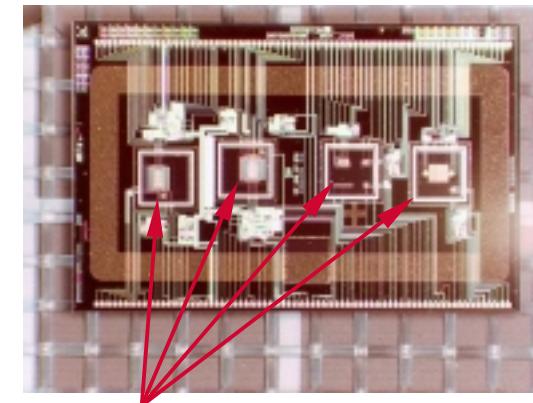


Product-Neutral Vacuum Packaging (Raytheon, et al.)

- ▶ Low-cost, mass-produced, high reliability
- ▶ Meets IR MEMS, RF MEMS, Inertial MEMS requirements
- ▶ Demonstrated <10 mTorr for 31 months, survived 10,000-g shock



Wafer-level vacuum-packaged 120x160 a-Si microbolometer arrays

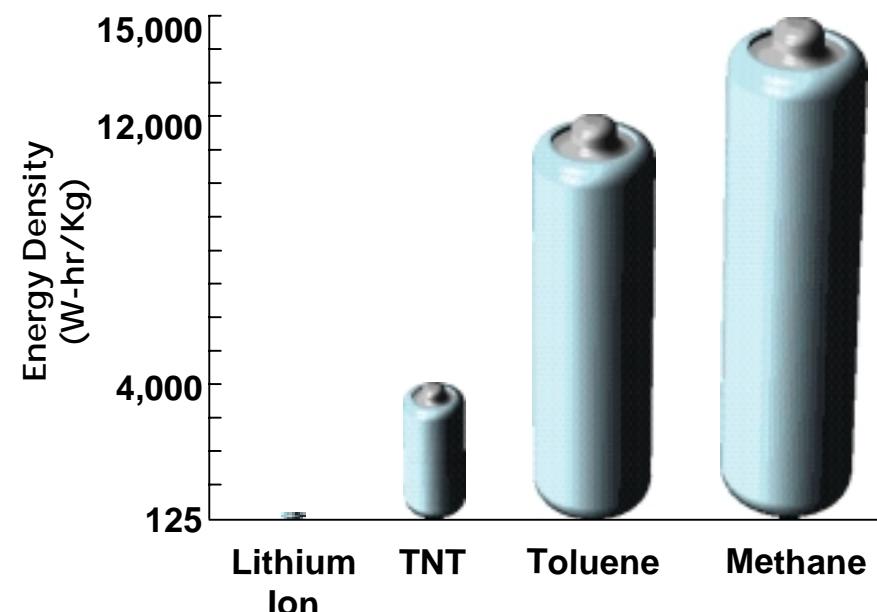
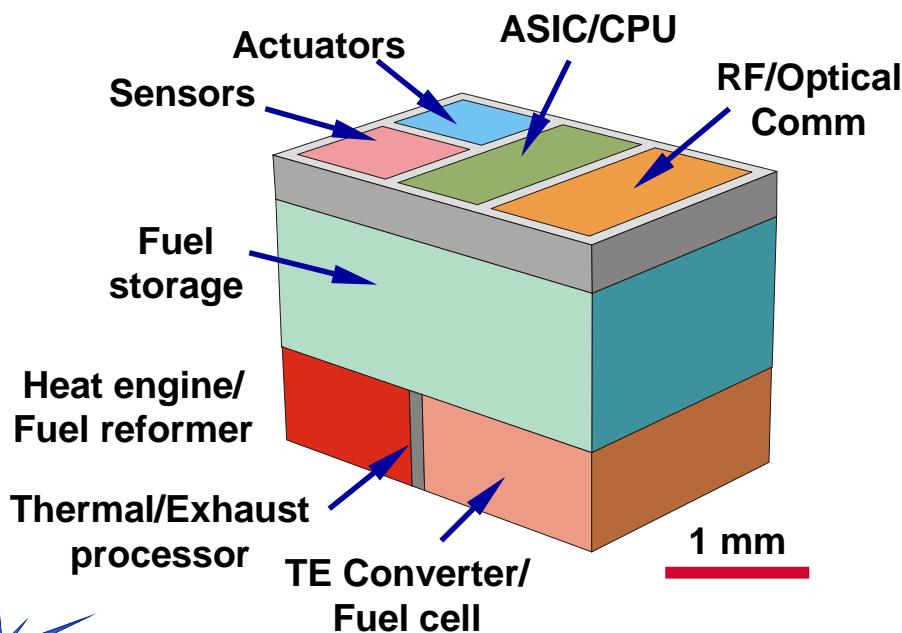


Microshell vacuum-packaged accelerometers, gyroscopes, & resonators



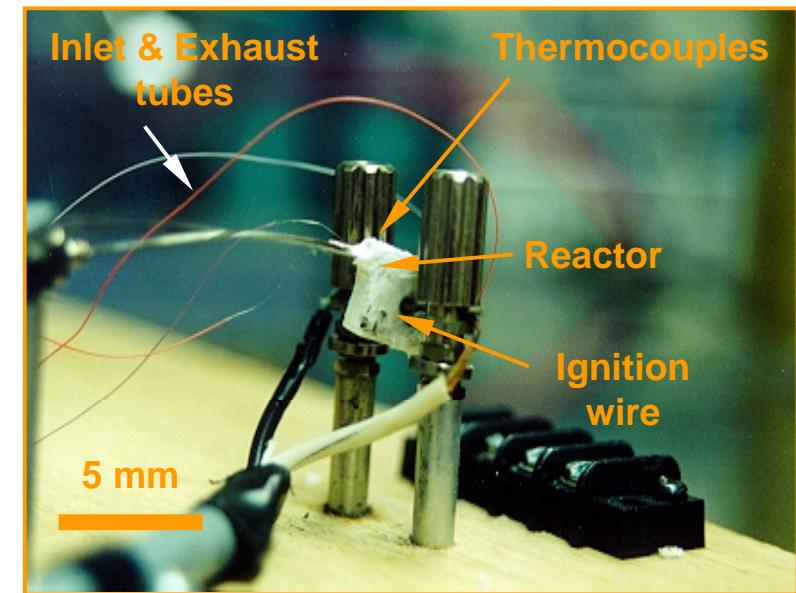
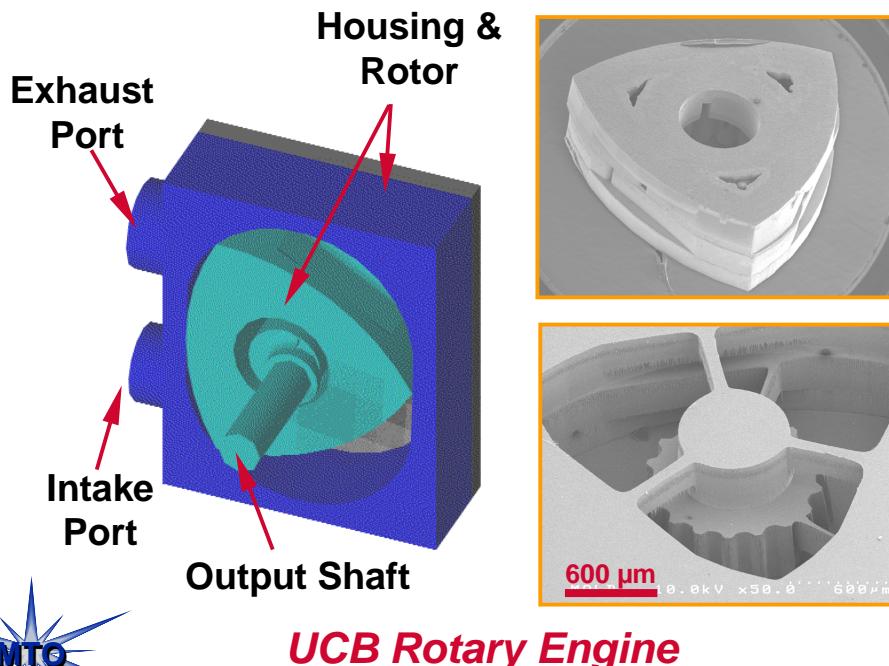
Micro Power Generation (MPG)

- Generate power at the micro scale to enable stand-alone micro sensors and micro actuators with wireless communication to realize new systems and strategies for weapons systems, processes, and battlefield environments.



Microcombustion (UC Berkeley, Princeton, et al.)

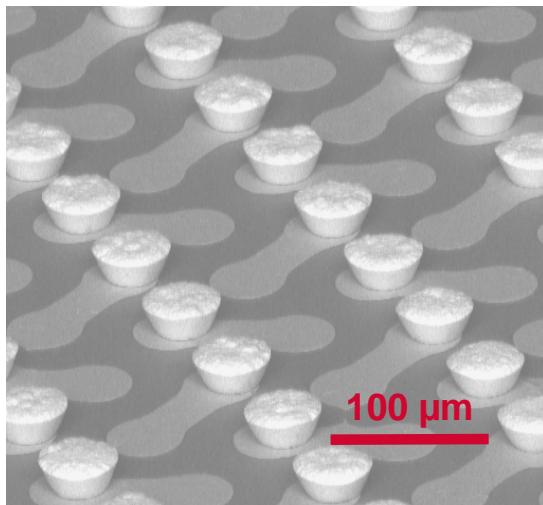
- ▶ Demonstrated fabrication techniques of high-temp materials (SiC at UCB, alumina at Princeton).
- ▶ Demonstrated self-sustained combustion in 1 mm³ chamber (H₂/Air, Princeton).



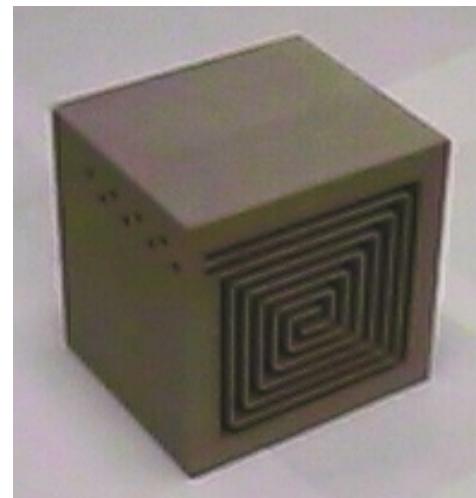
Alumina reactor with 200-μm-wide Pt-coated square channels (Princeton)

Thermoelectric Conversion (USC, et al.)

- ▶ Demonstrated counterflow Swiss-roll combustor
- ▶ Pursuing fabrication compatibility with thermoelectric elements (Bi_2Te_3)



*USC/JPL
micro TE elements*



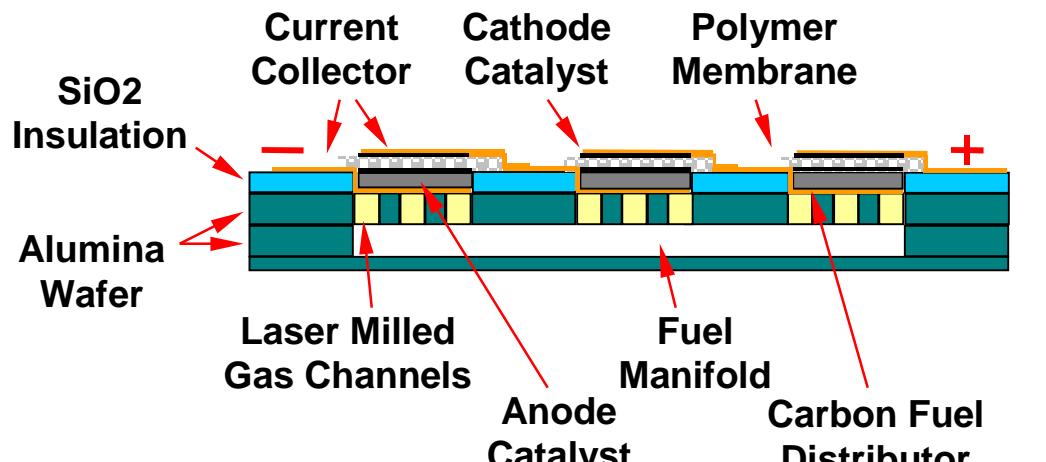
*USC macro
Swiss-roll combustor*



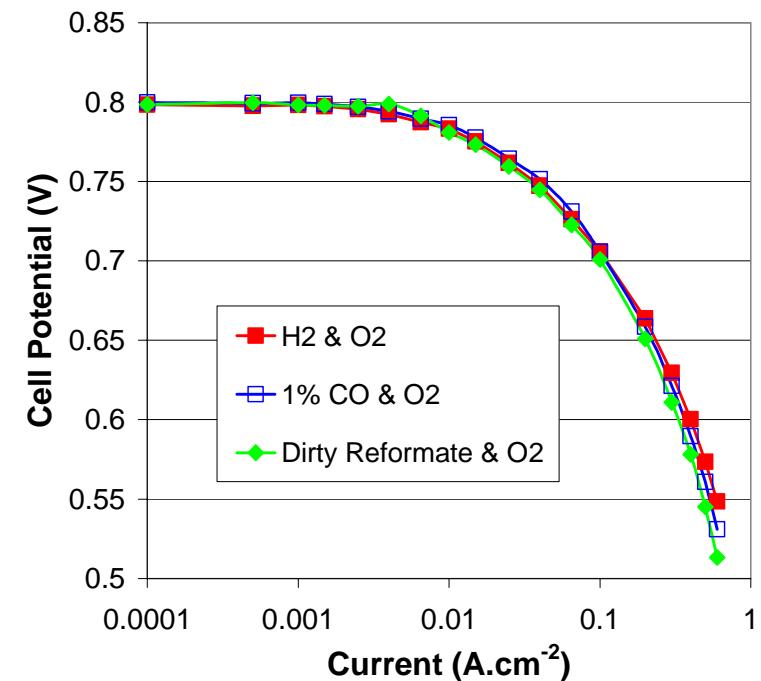
*Simulation of
combustion*

Micro Fuel Cells (CWRU, et al.)

- ▶ Demonstrated fabrication of micro fuel cells with built-in super capacitor & PdH layer as H₂ source
- ▶ Demonstrated high-temperature (>130°C) fuel cell operation in the presence of CO



CWRU micro fuel cell with palladium hydride



The Future of MEMS at DARPA

- ❖ Continue existing commitment
 - Maturing projects
 - New thrust: Micro Power Generation
- ❖ Emphasize transition
 - Into DoD systems
 - Into industry
- ❖ Establish new programs
 - Programs enabled by MEMS